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08/801,812	02/14/1997	JOHN H. GIVENS	11675.106	6774

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EXAMINER

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ART UNIT PAPER NUMBER

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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Paper No. 20031223

Application Number: 08/801,812
Filing Date: February 14, 1997
Appellant(s): GIVENS, JOHN H.

John H. Givens
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 10/17/2003.

(1) *Real Party in Interest*

A statement identifying the real party in interest is contained in the brief.

(2) *Related Appeals and Interferences*

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) *Status of Claims*

The statement of the status of the claims contained in the brief is correct.

(4) *Status of Amendments After Final*

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) *Summary of Invention*

The summary of invention contained in the brief is correct.

(6) *Issues*

The appellant's statement of the issues in the brief is correct.

(7) *Grouping of Claims*

Appellant's brief includes a statement that claims 1-15 and 36-45, claims 16-28 and 57-63, and claims 46-56 stand or fall together.

(8) *Claims Appealed*

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) *Prior Art of Record*

5,869,395	Yim, Randy M.	02-1999
6,217,721 B1	Xu et al.	04-2001

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1, 3-5, 7-11 and 36-45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Xu et al. (U.S. 5,847,461, hereinafter Xu '461) in view of Xu et al. (U.S. 6,217,721, hereinafter Xu '721).

Xu '461 (Figs.1-4) in a related method to form an interconnect teach forming a recess (14) within a dielectric material (10) situated on a semiconductor lower substrate (2), wherein said recess (14) extends below a top surface (12) of said dielectric material (10); forming a diffusion barrier layer (20) comprising titanium nitride on the recess (14) within the dielectric material (10); forming an electrically conductive layer (30) comprising aluminum on the barrier layer (20), wherein the diffusion barrier layer (20) has a melting point greater than that of the electrically conductive layer (30); forming an energy absorbing layer (40) on said electrically conductive layer (30), wherein said energy absorbing layer (40) has a greater thermal absorption capacity than that of said

electrically conductive layer (30) and wherein said energy absorbing layer (40) is selected from the group consisting of titanium, tungsten, silicon dioxide and tantalum; using a furnace to apply energy omnidirectionally to said energy absorbing layer (40) causing said electrically conductive layer (30) to flow within said recess (14); and removing portions of the energy absorbing layer (40) and the electrically conductive layer (30) that are situated above the top surface of the dielectric material (10) (column 3, line 12 – column 7, line 45).

Xu '461 fail to teach the steps of heating the diffusion barrier layer in an environment substantially containing nitrogen gas; forming a seed layer comprising titanium nitride on the diffusion barrier layer, wherein the diffusion barrier layer has a melting point greater than or equal to the seed layer; forming an electrically conductive layer on the seed layer including the portion of the seed layer within said recess, wherein the seed layer has a melting point greater than or equal to that of the electrically conductive layer.

However, Xu '721 (Fig.8) in a related method to form an interconnect teach the steps of heating a diffusion barrier layer (162) in an environment substantially containing nitrogen gas; forming a seed layer (164) comprising titanium nitride on a diffusion barrier layer (164), wherein the diffusion barrier layer (162) has a melting point greater than or equal to that of the seed layer (164); and forming an electrically conductive layer (156) on the seed layer (164) including the portion of the seed layer (164) within a recess (152), wherein the seed layer (164) has a melting point greater than or equal to that of the electrically conductive layer (156) (column 3, line 65 – column 6, line 45).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer, and having the thermal properties as taught by Xu '721 in the interconnect formation method of Xu '461, since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface (column 9, lines 39-45) and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures (column 6, lines 40-45).

3. Claims 2, 6 and 12-15 rejected under 35 U.S.C. 103(a) as being unpatentable over Xu '461 in view of Xu '721 as applied to claims 1, 3-5, 7-11 and 36- 45 above, and further in view of Yim (U.S. 5,869,395).

Xu '461 in combination with Xu '721 substantially teach all aspects of the invention but fail to teach that the diffusion barrier layer and the seed layer are deposited on the recess by a chemical vapor deposition process; that a chemical-mechanical polishing is used to remove portions of the energy absorbing layer and the electrically conductive layer; that the recess has an aspect ratio greater than about four to one; and that the recess comprises a contact hole situated below a trench, wherein said semiconductor substrate has a lower substrate and terminates at an opposite end thereof at said trench, and wherein said trench extends from said opposite end of said contact hole to a top surface of said dielectric material and parallel to the plane of the lower substrate.

However, Yim (Figs.2A-2K) in a related method to form an interconnect structure teaches the steps of depositing titanium nitride by a chemical vapor deposition process; using chemical-mechanical polishing to remove portions overlaying a damascene trench formed on a dielectric layer (210); providing a recess comprising a contact hole (260) situated below a trench (240); providing a semiconductor substrate (200) having a lower substrate (202) and terminating at an opposite end thereof at said trench (240), wherein said trench (240) extends from said opposite end of said contact hole (260) to a top surface of said dielectric material (210), and parallel to the plane of the lower substrate (202) (column 4, line 26 – column 7, line 31). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to deposit titanium nitride by chemical vapor deposition, using chemical mechanical polish to remove portions of conductive material overlying the dielectric layer and forming a recess comprising a trench and a contact hole as taught by Yim in the interconnect method of Xu '461 and Xu '721, since this would result in a damascene opening with an alignment tolerance, reduced processing time and a flat topography (column 3, line 49 – column 4, line 5).

Still, the combination of Xu '461 Xu '721 and Yim fail to teach that the recess has an aspect ratio greater than about four to one. However, one of ordinary skill in the art at the time the invention was made would have been led to the claimed invention through routine experimentation to achieve desired device dimensions and therefore desired device density and desired device characteristics on the finished wafer. Also, it would have been an obvious matter of design choice bounded by well known

manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, *In re Rose*, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); *Gardner v. TEC Systems, Inc.*, 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984); *In re Dailey*, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

4. Claims 16-28 and 57-63 are rejected under 35 U.S.C. 103(a) as being unpatentable over Xu '461 in view of Xu '721 and Yim ('395).

Xu '461 (Figs.1-4) in a related method to form an interconnect teach patterning and etching a dielectric material (10) comprising silicon oxide situated on a semiconductor substrate assembly (2) so as to form a recess (14) within the dielectric material (10); depositing a diffusion barrier layer (20) comprising titanium nitride within the recess (14) within the dielectric material (10); depositing an electrically conductive layer (30) comprising aluminum on the barrier layer (20) within said recess (14), wherein the diffusion barrier layer (20) has a melting point greater than that of the electrically conductive layer (30); depositing an energy absorbing layer (40) on said electrically conductive layer (30), wherein said energy absorbing layer (40) has a greater thermal

absorption capacity than that of said electrically conductive layer (30) and wherein said energy absorbing layer (40) is selected from the group consisting of titanium, tungsten, silicon dioxide and tantalum; using a furnace to heat omnidirectionally the energy absorbing layer, causing said conductive layer (30) to flow within said recess (14); and removing portions of the energy absorbing layer (40) and the electrically conductive layer (30) that are situated above the top surface of the dielectric material (10) (column 3, line 12 – column 7, line 45).

Xu '461 fail to teach the steps of heating the diffusion barrier layer in an environment substantially containing nitrogen gas; forming a seed layer comprising titanium nitride on the diffusion barrier layer, wherein the diffusion barrier layer has a melting point greater than or equal to that of the seed layer; forming an electrically conductive layer on the seed layer including the portion of the seed layer within said recess, wherein the seed layer has a melting point greater than or equal to that of the electrically conductive layer.

However, Xu '721 (Fig.8) in a related method to form an interconnect teach the steps of heating a diffusion barrier layer (162) in an environment substantially containing nitrogen gas; forming a seed layer (164) comprising titanium nitride on a diffusion barrier layer (164), wherein the diffusion barrier layer (164) has a melting point greater than or equal to that of the seed layer (164); and forming an electrically conductive layer (156) on the seed layer (164) including the portion of the seed layer (164) within a recess (152), wherein the seed layer (164) is composed has a melting point greater

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than or equal to that of the electrically conductive layer (156) (column 3, line 65 – column 6, line 45).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer and having the thermal properties as taught by Xu '721 in the interconnect formation method of Xu '461, since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface (column 9, lines 39-45) and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures (column 6, lines 40-45).

Still, the combination of Xu '461 and Xu '721 fail to teach using chemical-mechanical polishing to remove portions of the energy absorbing layer and the electrically conductive layer; and providing a recess comprising a contact hole situated below a trench, wherein said semiconductor substrate has a lower substrate and terminates at an opposite end thereof at said trench, wherein said trench extends from said opposite end of said contact hole to a top surface of said dielectric material and parallel to the plane of the lower substrate. However, Yim (Figs.2A-2K) in a related method to form an interconnect structure teaches the steps of using chemical-mechanical polishing to remove portions overlaying a damascene trench formed on a dielectric layer (210); providing a recess comprising a contact hole (260) situated below a trench (240); providing a semiconductor substrate (200) having a lower substrate (202) and terminating at an opposite end thereof at said trench (240), wherein said

trench (240) extends from said opposite end of said contact hole (260) to a top surface of said dielectric material (210) and parallel to the plane of the lower substrate (202) (column 4, line 26 – column 7, line 31). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to use chemical mechanical polish to remove portions of conductive material overlying the dielectric layer and forming a recess comprising a trench and a contact hole as taught by Yim in the interconnect method of Xu '461 and Xu '721, since this would result in a damascene opening with an alignment tolerance, reduced processing time and a flat topography (column 3, line 49 – column 4, line 5).

5. Claims 46-56 are rejected under 35 U.S.C. 103(a) as being unpatentable over Xu '461 in view of Xu '721 and Yim ('395).

Xu '461 in a related method to form an interconnect teach the steps of forming a dielectric material (10) over a semiconductor substrate (2) and having a top surface; forming a recess (14) within the dielectric material (10) extending from the top surface of the dielectric material (10) to the semiconductor substrate (2); filling the recess (14) with an electrically conductive material (30), wherein filling the recess (14) is performed by causing the electrically conductive material (30) to flow within the recess (14) by applying omnidirectional heating (column 3, line 12 – column 7, line 45).

Xu '461 fail to teach the steps of heating the diffusion barrier layer in an environment substantially containing nitrogen gas; forming a seed layer comprising titanium nitride on the diffusion barrier layer, wherein the diffusion barrier layer has a melting point greater than or equal to that of the seed layer; forming an electrically

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conductive layer on the seed layer including the portion of the seed layer within said recess, wherein the seed layer has a melting point greater than or equal to that of the electrically conductive layer.

However, Xu '721 (Fig.8) in a related method to form an interconnect teach the steps of heating a diffusion barrier layer (162) in an environment substantially containing nitrogen gas; forming a seed layer (164) comprising titanium nitride on a diffusion barrier layer (164), wherein the diffusion barrier layer (164) has a melting point greater than or equal to that of the seed layer (164); and forming an electrically conductive layer (156) on the seed layer (164) including the portion of the seed layer (164) within a recess (152), wherein the seed layer (164) is composed has a melting point greater than or equal to that of the electrically conductive layer (156) (column 3, line 65 – column 6, line 45).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a seed layer after the formation of the barrier layer and prior to the formation of the conductive layer and having the thermal properties as taught by Xu '721 in the interconnect formation method of Xu '461. since heating the barrier layer in a nitrogen environment substantially reduces the electronic barrier at the metal-semiconductor interface (column 9, lines 39-45) and the addition of titanium nitride as a seed layer improves the flow of aluminum into an interconnect at moderate temperatures (column 6, lines 40-45).

Still, the combined teachings of Xu '461 and Xu '721 fail to provide a recess including a first portion having an uniform width and extending within the dielectric

material to the top surface of the dielectric material and a second portion having a height and a uniform width that is less than the width of the first portion and that is not greater than 25% of the height, wherein the second portion extends from the semiconductor substrate to terminate at the first portion, and wherein the first portion is a trench having a bottom surface that extends longitudinally parallel to the top surface of the dielectric material, and that the second portion is a contact plug.

However, Yim (Figs.2A-2K) provide a recess including a first portion (240) having an uniform width and extending within the dielectric material (210) to the top surface of the dielectric material (210) and a second portion (260) having a height and a uniform width that is less than the width of the first portion (240), wherein the second portion (260) extends from the semiconductor substrate (202) to terminate at the first portion (240), and wherein the first portion (240) is a trench having a bottom surface that extends longitudinally parallel to the top surface of the dielectric material (210), and that the second portion (260) is a contact plug. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention was made to form a recess comprising a trench and a contact hole as taught by Yim in the interconnect method of Xu '461 and Xu '721, since this would result in a damascene opening with an alignment tolerance, reduced processing time and a flat topography (column 3, line 49 – column 4, line 5).

Still, the combination of Xu '461 Xu '721 and Yim fail to teach that and that the width of the first portion is not greater than 25% of the height. However, one of ordinary skill in the art at the time the invention was made would have been led to the claimed

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invention through routine experimentation to achieve desired device dimensions and therefore desired device density and desired device characteristics on the finished wafer. Also, it would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, *In re Rose*, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); *Gardner v. TEC Systems, Inc.*, 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984); *In re Dailey*, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

(11) Response to Argument

Appellant's arguments filed 07/17/2003 have been fully considered but they are not persuasive.

Appellant argues, "...Xu '461 specifically teaches that a seed layer is undesirable when filling small openings and is directed toward other methods of filling the contact openings. Appellant submits that the combination of Xu '461 and Xu '721 is improper because Xu '461 specifically teaches away from the use of a seed layer when extruding conductive material into very small contact openings. Thus, one of skill in the art would

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not be motivated to apply a seed layer under the metal layer 30 of Xu '461 in view of the fact that a seed layer is specifically taught against...". This argument is respectfully traversed because, although not taught as a preferred embodiment, Xu '461 teach this embodiment nonetheless, and disclosed examples and preferred embodiments do not constitute a teaching away from a broader disclosure or nonpreferred embodiments. In re Susi, 169 USPQ 423 (CCPA 1971). "A known or obvious composition does not become patentable simply because it has been described as somewhat inferior to some other product for the same use." In re Gurley, 31 USPQ2d 1130, 1132 (Fed. Cir. 1994). A reference may be relied upon for all that it would have reasonably suggested to one having ordinary skill the art, including nonpreferred embodiments. Merck & Co. v. Biocraft Laboratories, 874 F.2d 804, 10 USPQ2d 1843 (Fed. Cir.), cert. denied, 493 U.S. 975 (1989). Even a teaching away from a claimed invention does not render the invention patentable. See Celeritas Technologies Ltd. v. Rockwell International Corp., 150 F.3d 1354, 1361, 47 USPQ2d 1516, 1522-23 (Fed. Cir. 1998), where the court held that the prior art anticipated the claims even though it taught away from the claimed invention. "The fact that a modem with a single carrier data signal is shown to be less than optimal does not vitiate the fact that it is disclosed." To further clarify, a prior art opinion that a claimed invention is not preferred for a particular limited purpose, does not preclude utility of the invention for that or another purpose, or even preferability of the invention for another purpose.

Also, appellant argues, "...Yim does not teach or suggest the use of any seed layer. Thus, the further combination of the teachings of Yim would fail to achieve the

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claimed invention...". In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986).

Furthermore, appellants argue, "...the recited range in claim 46 would not be a matter of routine experimentation, since there are many permutations of the width/height of a multi-portion recess that could be formed. Thus, taking official notice with respect to the recited range in claim 46 is improper since such a range is not "capable of instant and unquestionable demonstration as being well-known." M.P.E.P. § 2144.03 (A). In response to this argument, the reliance on the official notice is withdrawn. Notwithstanding, it would have been an obvious matter of design choice bounded by well known manufacturing constraints and ascertainable by routine experimentation and optimization to choose these particular dimensions because applicant has not disclosed that the dimensions are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical, and it appears prima facie that the process would possess utility using another dimension. Indeed, it has been held that mere dimensional limitations are prima facie obvious absent a disclosure that the limitations are for a particular unobvious purpose, produce an unexpected result, or are otherwise critical. See, for example, *In re Rose*, 220 F.2d 459, 105 USPQ 237 (CCPA 1955); *In re Rinehart*, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976); *Gardner v. TEC*

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Systems, Inc., 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S.

830, 225 USPQ 232 (1984); In re Dailey, 357 F.2d 669, 149 USPQ 47 (CCPA 1966).

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Julio J. Maldonado
Examiner
Art Unit 2823

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December 29, 2003

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